

10/p212

# A TELESCOPIC GUIDE PIPE FOR OFF-SHORE DRILLING

The present invention relates to the known field of off-shore drilling from an anchored support floating on the surface, and more particularly it relates to devices  
5 installed at sea bottom level for guiding drill strings.

More particularly, the invention relates to deflected drilling in deep water so as to reach points that are far away from vertically beneath the drilling equipment on the surface.

10 Once the depth of water becomes large, exploring and working production fields, in particular oil fields, is generally carried out from a floating support. In general, the floating support has anchor means for keeping it in position in spite of the effect of  
15 currents, winds, and swell.

During drilling operations, it also generally has means for handling drill strings, and guide equipment associated with safety systems installed on the sea bottom.

20 Drilling is usually carried out vertically beneath the drilling equipment, and then penetrates into the ground vertically over a height of several hundreds of meters. Thereafter, drilling is continued until the petroleum deposit referred to as the "reservoir", either  
25 in a vertical direction or else with a progressively increasing angular deflection so as to reach points of said reservoir that are offset to a greater or lesser extent.

The stage of starting a well is generally performed  
30 by lowering from the surface a drilling bedplate that rests on the sea bottom and that is provided with guide lines going to the surface, after which a length of pipe referred to as "casing" is lowered, this pipe being of large diameter, generally 36 inches ("") (= 0.914 meters  
35 (m)) having a total length of 50 m to 60 m. The casing is made up from unit lengths of pipe, each measuring about 12 m long, which unit lengths are assembled

together by screw engagement on board the drilling platform, at derrick floor level. In order to withstand forces, each unit length of casing has, at each of its ends, a zone that is reinforced over a length of 0.5 m to 1 m, which reinforced zone is constituted by extra thickness corresponding to about half to twice the ordinary thickness of the wall of said casing, with said screw thread being machined in said thickness. Once assembled, said casing passes through said baseplate and is then simply put into the ground, which is generally quite loose, so driving can often be performed by merely jetting (i.e. by squirting water under pressure). The first length of casing serves to consolidate the walls of the well in its zone close to the sea bottom, and thus acts as a device for guiding a second length of casing which is smaller in diameter and generally has a total length of 150 m to 200 m, said second length of casing itself also being built up by assembling together 12 m unit lengths of pipe having reinforced end zones and presenting an outside diameter, including the reinforced threaded zones, that is significantly smaller than the inside diameter of the outer casing so as to enable it to slide freely during installation, and also so that cement slurry can be delivered under good conditions. The second casing is then either vibro-driven, or else it is driven by drilling if the ground requires drilling, and then the gap between said casings and the ground is cemented from the surface, as is the gap between said two casings. During these stages, the work is "open-hole" work and there is a risk of being exposed to ground instability, or indeed to unwanted ingress of water at shallow depth beneath the sea bottom ("shallow water flow"), which can severely disturb the stage of starting the well.

Depending on the nature of the ground, it may be necessary to consider using a third length of casing or

even a fourth in order to reach a sufficient depth for initiating drilling proper.

Thus, the multiple lengths of casing present large gaps between each of said lengths and the next, and in addition, because each of said length of casing extends from sea bottom level down to its own bottom end, this implies that at sea bottom level and over the full height of the first length of casing and of the subsequently installed lengths, there exist radially two, three, or even four or more successive thicknesses of casing which are not useful in subsequent operations since during the main stages of drilling and operating the well, only one thickness of casing is needed to support downhole equipment and to seal the assembly. These multiple redundant layers of casing in the zone close to the sea bottom are made necessary by the way in which well drilling is started in prior art methods, and this redundancy represents a considerable quantity of steel, and thus a very high cost.

Patent GB-2 338 009 describes a way of installing multiple independent casing elements that are installed successively one inside another with small clearance. Said elements are installed in sequence, one after the other, and because of the small clearance, this makes it possible to minimize the maximum diameter of the hole that is to be drilled, both for the outermost casing element and for the intermediate casing element, thereby correspondingly reducing the quantity of drilling waste to be removed and the power requirements of the drilling equipment, and consequently reducing hourly operating costs.

Patent US-5 307 886 describes a system and a method of installation enabling multiple casing elements to be used with small clearance, and minimizing the space between said casing and the wall of the hole drilled in the ground.

A first problem on which the invention is based is to provide a guide device enabling a drill string and a drilling tool to be guided as deeply as possible into the subsoil at the bottom the sea so as to avoid such accidents of unwanted ingress of water that occur at shallow depths in the ground while casing is being installed.

Another problem is to reduce the amount of handling and assembly performed on board the drilling platform of unit lengths of pipe serving to make up said lengths of casing, thereby reducing the difficulty, the duration, and therefore the cost of installing casing, particularly in ultra-great depths, i.e. in depths of 2000 m to 3000 m, or even more. Since such handling is performed in successive independent sequences, and even when the time spent specifically in burying the first length of casing in the ground, and then the second length of casing, etc. remains acceptable, the intermediate handling consisting in raising gripping tools to the surface and then lowering the following length of casing then represents a considerable amount of time and thus a considerable cost of not using the extremely expensive drilling equipment, particularly when the depth of water is 2000 m, 3000 m, or even 4000 m to 5000 m, or more. In addition, the stages of cementing the gap between two lengths of casing requires a very large amount of time, thereby increasing the cost of the operation.

Another problem is to greatly reduce the quantity of steel needed for making such casing by minimizing redundancy and also the clearance between successive lengths of said casing.

Furthermore, when drilling a plurality of deflected wells, it is possible to set up an array of wells in an umbrella shape, all stemming from a single position for the floating support on the surface, thus making it possible throughout working of the field to group together all of the surface equipment in the same

location. Such installations are referred to as dry tree units (DTUs) because the wellheads are dry since they are brought together at the surface out of the water. This makes working much easier since it is possible to access any one of the wells from DTU in order to perform all of the maintenance and inspection operations required on wells, and this can continue throughout the lifetime of the installation which can be as much as 20 years to 25 years or even longer.

Such deflected drilling is possible only if the reservoirs are at great depth, for example 2000 m to 2500 m, since it is essential to have a borehole with a vertical length of several hundreds of meters in the sea bottom prior to initiating deflection of the well, and given that the radii of curvature used in deflected wells are of the order of 500 m to 1000 m.

Patents EP 0 952 300 and EP 0 952 301 describe methods and devices for drilling deflected wells by taking advantage of the depth of water in order to begin drilling as far away as possible from vertically below the drilling equipment, and in order to rest on the sea bottom in a manner that is substantially tangential to the horizontal.

In those patents, the guide devices installed on the sea bottom penetrate into the ground and enable the borehole to be started in the sea bottom while it is inclined at a given angle relative to the vertical. The guide device is connected to the drilling equipment by a pipe known as a drilling riser which guides the drill string that passes therealong and which serves to raise drilling mud and debris.

The guide element installed on the sea bottom must make it possible to comply with large radii of curvature of 500 m to 1000 m, and consequently it must be of large dimensions, while nevertheless remaining very strong in order to be able to accommodate the considerable forces generated by the drill string which is also constrained

to follow the same radius of curvature, thereby giving rise to very high levels of friction and to a risk of the assembly becoming destabilized during drilling.

5 In addition, that guide element of considerable size and mass needs itself to be pre-installed in ultra-great depth, i.e. in depths of water of 1000 m to 2500 m, or even more.

10 More precisely, in EP 0 952 301, the guide device includes a pipe element referred to as a "conductor" which is the borehole guide tube deployed from a floating support via the drilling riser down to a structure referred to as a "skid" resting on the sea bottom. Said skid structure holds and guides the conductor tube horizontally a certain height above the sea bottom. The  
15 conductor then takes up a curve towards the sea bottom under the effect of its own weight. While it is being deployed, the conductor co-operates with drilling tools so as to become partially buried in the sea bottom. Putting such a guide device into place, and in particular  
20 putting the conductor into place from the floating support represents a considerable operational constraint. In addition, the guide device provides no control over the curvature of the conductor. Furthermore, in order to ensure that the radius of curvature is large, and in  
25 particular greater than 5000 m, it is necessary for the conductor to be deployed tangentially to the horizontal over several tens of meters beyond the bearing point which guides it on the skid structure.

30 Finally, those patents do not describe any means for ensuring that said conductor is put into place with a large radius of curvature as is necessary for the drill string, and above all to allow the casing elements to operate with a minimum amount of lateral friction inside the pipe.

35 For a radius of 600 m, if the well head is 2 m above the ground, the conductor will reach the ground 50 m further away, which means that there is a free and

unsupported cantilevered-out portion of conductor that is 50 m long, which is not acceptable since there is a danger of the conductor breaking or kinking because of local curvature that is too sharp since it is not under control. In addition, the cantilevered-out portion can be harmful to proper operation during drilling operations and also throughout the lifetime of the well which might exceed 25 years.

Another problem of the present invention is thus to provide a guide device in an application to drilling in a manner that is deflected in the depth of the water, that can reliably be installed with a large radius of curvature, i.e. in which it is possible to ensure that the radius of curvature is greater than 500 m, in particular, and which is easy to build and put into place.

In a first aspect providing a solution to the problem of guiding the drill string and the drilling tool as deeply as possible, the present invention provides a guide device for an off-shore drilling installation comprising at least one drilling riser extending from a floating support to said guide device on the sea bottom, said drilling being performable from said floating support using a drill string fitted at its end with drilling tools passing through said drilling riser and said guide device, said guide device being characterized in that it comprises a telescopic guide pipe comprising coaxial telescopic guide elements about an axis XX' and of decreasing diameters, the elements being preassembled one in another in such a manner that said telescopic pipe elements are suitable for sliding in the direction of said axis XX' one inside another, the smallest-diameter, innermost telescopic pipe element being fitted at its end with breakup means for breaking up the ground suitable for enabling said telescopic guide pipe to be progressively buried in the ground by sliding said telescopic pipe elements outwards, thereby enabling a

drilling tool at the end of said drill string to be guided more deeply in the ground.

It will be understood that the guide pipe is buried progressively in the ground from a retracted initial position in which the smallest-diameter innermost telescopic pipe element is retracted inside the larger-diameter telescopic pipe elements. All of the telescopic pipe elements are thus positioned inside an outermost telescopic pipe element of largest diameter. The progressive burying of said breakup means takes place by progressively sliding the smaller-diameter elements out from the larger-diameter elements, and thus initially by sliding out the smallest-diameter innermost telescopic pipe element, and then progressively sliding out telescopic pipe elements of increasing diameters until all of the telescopic pipe elements are fully deployed in outward extension.

By proceeding in this way with a conventional vertical borehole, a single guide device is lowered from the surface instead of the two or three devices of the prior art, which represents a considerable saving in time when drilling in deep water, for example in depths of 2000 m, 3000 m, or even more, since those elements need to be lowered in succession. In addition, if the ground is unstable, or indeed if shallow water flow occurs, since the casing is continuous over its entire length, the risk of collapse is considerably reduced, or even completely eliminated. Finally, the operations of cementing the device of the invention are reduced to a minimum since it is no longer necessary to perform cementing after each length of casing has been put into place in the preceding length, as is the case with the lengths of casing in the prior art. Cementing is performed once only, after the telescopic device has been fully deployed.



In a preferred embodiment, said smallest-diameter innermost pipe element presents a diameter substantially equal to the diameter of said drilling riser.

5 In a particular embodiment, said means for breaking up the ground are constituted by a multiply-perforated capsule enabling water or mud to be jetted into the ground by being injected under very high pressure.

More particularly, said telescopic guide pipe has at least three coaxial telescopic pipe elements.

10 Still more particularly, each of said telescopic coaxial pipe elements presents a length of 50 m to 300 m, preferably of 100 m to 200 m, said deployed guide pipe presenting a length of 150 m to 600 m, and preferably of 200 m to 300 m. The guide device of the invention is  
15 initially prefabricated on land, then put into the retracted configuration by inserting the pipes one inside another so as to reduce total length to a minimum, and then put in the water and fitted with buoyancy elements, after which it is towed to the site so as to be on the  
20 axis of the drilling derrick, where it is finally upended in such a manner that the top portion of said telescopic pipe can be taken hold of by the handling tool installed at the end of the drill string handled by the derrick, with the assembly then being lowered in a single  
25 operation in a vertical configuration to the guide baseplate resting on the sea bottom.

Since prefabrication takes place on land, with each of said telescopic pipe elements being built up by assembling successive unit lengths of pipe, said unit  
30 lengths are merely welded together end to end in conventional manner, like when making pipe lines. There is thus no need to reinforce the ends of each 12 m unit length since there is no thread to be machined therein, so the assembly presents optimum diameter that is greatly  
35 reduced compared to the prior art.

The term "retracted telescopic guide pipe" is used to mean that the various preassembled telescopic pipe

elements are arranged in such a manner that the smaller-diameter elements are inside the larger-diameter elements.

5 In a second aspect, serving to solve the problem of putting a guide device into place in an application to drilling a borehole that is deflected in the depth of the water, the present invention provides a guide device that is useful in an off-shore drilling installation, an installation in which at least one drilling riser extends  
10 from a floating support to a said guide device at the sea bottom, said drilling riser deflecting progressively from a substantially vertical position at said floating support to a position that is substantially horizontal or tangential to the horizontal at the sea bottom, said  
15 drilling being performable from said floating support via said drilling riser and said guide device in such a manner that the borehole in the sea bottom is begun at a given angle of inclination  $\alpha$  relative to the horizontal that preferably lies in the range  $5^\circ$  to  $60^\circ$ , and more  
20 preferably in the range  $25^\circ$  to  $45^\circ$ , said guide device being characterized in that it comprises a said telescopic guide pipe in a buried position in which said telescopic guide pipe in the retracted position or the outer telescopic pipe element when said telescopic pipe  
25 is deployed, comprises in succession:

- a front end resting substantially horizontally on the sea bottom;

- a curved intermediate portion buried in the subsoil of the sea bottom with a large radius of  
30 curvature, preferably a radius of curvature greater than 500 m; and

- a rear portion that is substantially linear and buried in the subsoil of the sea bed at said given angle of inclination  $\alpha$ ;

35 said telescopic guide pipe or said outer telescopic element co-operating with controlled burying means enabling said retracted telescopic guide pipe to be

buried in the sea bottom while said retracted telescopic guide pipe is being towed along the sea bottom from its front end, starting from an initial position in which said retracted telescopic guide pipe rests entirely on the sea bottom in a substantially horizontal position, to a said buried position in the subsoil of the sea bottom.

The curvature of the telescopic guide pipe is thus determined by controlled burying of the guide pipe. Because of the considerable length of said guide pipe in the retracted position, each of the retracted segments can take up the same curvature without generating significant levels of force within the assembly.

The means for burying the retracted telescopic guide pipe make it possible, by burying the pipe, to obtain pipe curvature having a large radius of curvature that is of a desired and controlled value, given that the radius of curvature depends on the characteristics and the arrangement of said burying means.

It will be understood that said inclined linear portion extends tangentially from said curved portion and it is the angle of inclination of said linear portion which determines said starting angle  $\alpha$  of the borehole.

It will also be understood that the term "horizontal at the sea bottom" means a position that is substantially horizontal as a function of the relief of the sea bottom.

In a particular embodiment, said guide pipe presents a length of 100 m to 600 m, preferably of 250 m to 450 m, with a said given angle of inclination  $\alpha$  of the guide pipe lying in the range about  $10^\circ$  to  $60^\circ$ , and preferably in the range  $25^\circ$  to  $45^\circ$ . The desired curvature for the guide pipe then corresponds to an increase in inclination of about  $1^\circ$  per 10 m portion of the length of the guide pipe, giving a radius of curvature of about 560 m.

In a preferred embodiment, said front end of the retracted telescopic guide pipe is engaged in a baseplate carrying a load resting on a front soleplate such that said baseplate maintains said front end of said guide

pipe substantially horizontal on the sea bottom while it is being towed. Said baseplate prevents the front end of said retracted telescopic guide pipe becoming buried, and also prevents it from turning about a substantially  
5 horizontal axis perpendicular to the towing axis.

The present invention also provides a method of making a guide device of the invention, the method being characterized in that the following steps are performed:

- placing a said telescopic guide pipe in the  
10 retracted position in a said initial position where it rests substantially horizontally and in rectilinear manner on the sea bottom, said telescopic guide pipe co-operating with said controlled burying means; and
- towing the front end of said telescopic guide pipe  
15 in the retracted position along the sea bottom, preferably in the axial longitudinal direction XX' of said guide pipe, from said initial position to a said buried position.

The present invention also provides an off-shore  
20 drilling installation comprising a drilling riser extending from a floating support to a guide device of the invention to which said drilling riser is connected.

For drilling that is deflected in the depth of water, said drilling riser deflects progressively from a  
25 substantially vertical position at said floating support to a position that is substantially horizontal or tangential to the horizontal at the sea bottom, drilling being performable from said floating support via said drilling riser and said guide device in such a manner  
30 that a borehole begins in the sea bottom at a given angle of inclination  $\alpha$  relative to the horizontal, preferably lying in the range  $10^\circ$  to  $80^\circ$ .

The present invention also provides a method of making a drilling installation of the invention,  
35 characterized in that the following steps are performed:

- making a telescopic guide device using a method of the invention; and

- connecting at least said drilling riser to said front end of the telescopic guide device resting on the sea bottom.

Finally, the present invention provides a method of drilling with the help of a drilling installation of the invention, the method being characterized in that drilling operations are performed and a borehole is constructed by deploying drill strings co-operating with drilling tools and columns of tubing via a said drilling riser and a said guide device buried in the sea bottom.

More precisely, it will be understood that the drill string serves initially to deploy the drilling tools, and subsequently to deploy the tube elements known as "casing" which constitute the borehole as drilling progresses and successive elements are put into place in the sea bottom.

Other characteristics and advantages of the present invention appear in the light of the following description of various embodiments given with reference to the accompanying figures, in which:

- Figure 1 shows a telescopic guide device constituted by telescopic coaxial pipe elements shown in the retracted position, for a conventional vertical borehole;

- Figures 2, 3, and 4 are side views in section showing details of the telescopic guide device in the retracted position, shown as a straight line, respectively when it is placed on the sea bottom, at the beginning of the operation of drilling by jetting, and during drilling with a rotary tool;

- Figure 5 is a side view in section of the telescopic guide device when partially deployed, shown in a straight line, showing details of the thrust forces acting on the various telescopic elements and on the drilling tool, during conventional vertical drilling;

- Figure 6A is a side view of a DTU type surface support fitted with a drilling riser connected to a guide

device pre-installed on the sea bottom for drilling in deep water with deflection taking place in the depth of water;

5       - Figure 6B shows a telescopic guide device made up of three telescopic coaxial pipe elements that are deployed for drilling that has been deflected in the depth of water;

10       - Figures 7 and 8 are side views of a guide device associated with an anchor for penetrating into the ground, shown respectively before and after penetration into the sea bottom;

      - Figures 9 and 10 are cross-section views through the guide device on respective section planes AA and BB;

15       - Figures 11 and 12 are side views of a guide device fitted with lateral fins providing varying penetration into the ground, shown respectively before and after penetration into the sea bottom;

20       - Figure 13 is a left-hand view of the guide device shown in Figures 11 and 12, showing lateral fins in detail;

      - Figure 14 is a side view of a guide device fitted with secondary jetting pipes for making it easier to break up the ground during the stage of penetrating into the sea bottom;

25       - Figure 15 is a cross-section view in an ordinary portion of the device shown in Figure 14;

30       - Figures 16 and 17 are side views of a structure associated with the guide device of Figures 7 and 8 for limiting depth of penetration into the ground, shown respectively before and after said penetration into the sea bottom;

      - Figures 18 and 19 are sections on planes CC and DD of Figure 16; and

35       - Figure 20 is a side view of a drilling platform installed vertically above the drilling space of a future well, showing the sequence whereby a telescopic guide device in the retracted position is installed, which

device is firstly prefabricated on land, then fitted with floats and towed to the site, then upended into a vertical position, and then finally suspended from the drilling platform, by means of a grip installed at the end of a drill string, the assembly then being ready for lowering along guide lines towards said drilling baseplate.

To clarify explanation, clearance between adjacent elements of the telescopic pipe has been exaggerated to a considerable extent in the figures so as to make it easier to understand how the sliding, guiding, and sealing means operate.

Figure 1 shows a guide device constituted by three telescopic pipe elements 3a, 3b, 3c in a straight-line position, suitable for use in the context of conventional vertical drilling. Said guide device 3 is constituted by three telescopic pipe elements 3a, 3b, and 3c, and it is suspended from a drilling riser 2 being handled by a derrick at the surface, and being lowered towards a drilling baseplate 45 resting on the sea bottom 4. First guide means 47 are initially lowered along guide cables 48 so as to become centered on guide posts 46, and finally rests directly on the baseplate. To clarify the drawing, the guide device 3 is shown in a position slightly above said baseplate 45, immediately prior to being placed thereon. This first guide means 47 is in the form of a funnel having a diameter slightly greater than the outside diameter of the portion of the guide device 3a of the guide device 3, and by co-operating therewith it enables the portion 3a to be guided as it is lowered onto the baseplate 45. While it is being lowered, the guide device 3 is secured to second guide means 49 engaged thereon in a plane DD and itself guided along the guide lines 48.

As shown in Figure 20, the guide device 3 is prefabricated on land, and then the various elements are entered one into another so that the length of the

assembly when retracted in this way is as short as possible, after which the guide device is put into the water and fitted with floats 50. It is then towed to the site, and close to the drilling platform 1, said guide  
5 device is upended by eliminating the forward floats and it is then transferred while vertical to the axis of the derrick, where it is taken hold of by the drill string 2 which is fitted at its end with a gripping tool.

In a preferred variant of the invention, the  
10 drilling platform 1 is replaced merely by a surface vessel, preferably with dynamic positioning, and the guide device 3 once upended is then suspended from a cable connected to a winch installed on board the vessel. The guide device is then lowered by cable as a simple  
15 pendulum, preferably without using guide lines, and is then inserted into the drilling baseplate. Penetration is started by jetting, with hydraulic power being delivered by the surface vessel and conveyed to the bottom, e.g. by means of a flexible hose. When jetting  
20 is no longer effective, the surface vessel ceases that operation, and the operation of installing the guide is subsequently terminated by the drilling platform once it reached the site, vertically over the well that is to be drilled. By proceeding in this way, the cost of putting  
25 casing into place is greatly reduced since the daily cost of a surface vessel represents a small fraction of the cost of a drilling platform capable of drilling in water at depths of 3000 m, 4000 m, or even more. In addition, the necessary drilling equipment can be of lower power  
30 and thus of reduced cost since it does not need to handle the telescopic guide device of the invention, nor even individual conventional casing elements as in the prior art.

Figure 2 shows a telescopic guide device 3 in its  
35 retracted or collapsed position with an orifice 31 enabling drilling mud and debris to be evacuated at the sea bottom. The telescopic pipe elements of said



telescopic guide pipe 3 are tubular and of diameters of decreasing sizes so as to be capable of sliding one in another. The intermediate telescopic pipe element 3b of the telescopic guide device 3 is provided on its front  
5 portion with a sealed sliding ring 32b providing low friction guidance to the end inside telescopic pipe element 3c of the telescopic guide device 3, and at its rear end, it has a non-sealing sliding ring 33b providing low-friction guidance for the outside telescopic pipe  
10 element 3a of said telescopic guide device 3.

The portion 3a of said guide device is fitted at its front end with a sealing sliding ring 32a for providing low friction guidance of the portion 3b and it is secured at its rear end to the drilling riser in a catenary  
15 configuration 2.

The portion 3c of said guide device is fitted at its front end with a capsule 35 that is pierced by multiple orifices, or indeed it is fitted with a series of nozzles making it possible merely by injecting water or mud under  
20 very high pressure to break up cohesion of the ground and thus enable the well to be started merely by jetting, and at its rear end it has a non-sealing sliding ring 33c.

Complementary sliding rings 34 are advantageously installed at optionally regular intervals, respectively  
25 between the portions 3a & 3b and 3b & 3c so that when the portions of the guide device are highly curved, as shown in Figure 1, there is no danger of the outside wall of an inner portion, e.g. 3b rubbing directly against the inside wall of an outer portion 3a. For the portion 3b,  
30 these sliding rings 34 are secured to said telescopic portion 3b in such a manner as to present a high level of friction relative to said portion 3b, i.e. they can slide providing they are subjected to a high level of force acting parallel to the longitudinal axis of said portion  
35 3b. Thus, when the portion 3b slides out from 3a, the sliding ring 34 comes into abutment against the sealed sliding ring 32a, and since it is capable of sliding

under a high level of force, outward sliding of 3b from within 3a is not prevented. At the end of sliding, all of the sliding rings 34 are in contact with said sliding ring 32a, the sliding ring 33b itself being in contact with said sliding ring 34. Each of the sliding rings 34 is advantageously provided in its outer portion with a low friction element 34<sub>1</sub> so as to minimize longitudinal contact forces between the walls of the various portions of the guide device 3 when it is significantly curved.

Figure 4 shows the stage when drilling starts, the guide device being installed in the sea bottom, the portions 3a, 3b, and 3c being in the retracted position.

The drilling tool 36 is secured to the bottom end of the drill string 38 and is actuated from the derrick installed on the surface on the floating support. Said drilling tool 36 is constituted by a turbine 36<sub>1</sub> actuated by fluid under pressure, in general drilling mud delivered by the drill string 38, actuating a tool carrier 36<sub>2</sub> having cutting tools 36<sub>3</sub> secured to the front face thereof and having a drum carrying retractable cutting tools 36<sub>4</sub> shown in the retracted position in Figure 3 and in the working position in Figure 4. A piston 40 (shown in Figure 5) is secured to the drill string 38 and slides inside the riser 2 so as to maintain sealing between the upstream and downstream sides of said piston 40.

Thus, at the beginning of the driving-drilling operation, the drilling tool 36 secured to the end of the drill string 38 is lowered from the surface so as to reach the position shown in Figure 3. The orifice 31 is closed by a valve (not shown) and a fluid is delivered under very high pressure via the drill string 38. The turbine 36<sub>1</sub> is run without load and the fluid can escape only via the capsule 35 which is pierced by a multitude of small holes. The jetting which thus takes place in front of the portion 3c of the guide device serves to break up the ground, and the piston effect due to the

increased internal pressure thrusts the portion 3c forwards, possibly also entraining the portion 3b of said guide device.

5       Once the jetting effect is no longer sufficient to  
cause the front section to advance, jetting is stopped  
and the drilling tool 36 is moved forwards by pushing  
down the appropriate length of drill string 38 from the  
surface. A centering collar 37a secured to the turbine  
10       36<sub>1</sub> slides freely inside the portion 3c of the guide  
device; said collar allows drilling mud and debris to  
pass freely in both directions from upstream to  
downstream. At the end of the advance stage, the collar  
37a comes into abutment against a string 37b secured to  
the portion 3c of the guide device, inside it. The  
15       collar 37a and the ring 37b present complementary  
threaded portions (not shown) so that merely by turning  
the drill string from the surface, it is possible to  
secure the turbine body 36<sub>1</sub> mechanically to the portion 3c  
of the telescopic guide device, as shown in Figure 4.  
20       During this operation of advancing the drill string 38,  
fluid continues to be injected under pressure, thus  
making it possible to use the rotating drill tool to  
destroy the jetting capsule 35, but care is taken to open  
the orifice 31 so that the drilling mud and residue can  
25       escape at sea bottom level.

      In order to make it easier for the tool 36 to  
advance inside the riser and then the portion 3c of the  
telescopic guide device 3, said riser and said guide  
portion are substantially identical in section, and  
30       centralizers 38a are advantageously installed that are  
secured to the drill spring and that slide freely in said  
riser. Since such centralizers are known to the person  
skilled in the art of drilling boreholes, they are not  
described in greater detail herein. -

35       In Figure 4, drilling has started and the extendible  
arms of the drilling tool 36<sub>4</sub> have been deployed so as to  
enlarge the borehole to a diameter that corresponds at

least to the diameter of the portion 3b of the guide device 3. Tool advance is advantageously controlled by using the derrick to adjust the length of the drill string at the surface. In order to increase thrust force, the annulus extending between the drilling riser and the drill string 38 is subjected to higher pressure from the surface. Thus, the pressure P established upstream from the leaktight piston 40 generates thrust F which, via the drill string 38, urges the tool forwards, thereby entraining the portions 3c and then 3b of the telescopic guide device until it is fully deployed, as shown in Figure 1.

In the final position, the drill string is operated from the surface to turn in the unscrewing direction so as to release the turbine body 36<sub>1</sub> from the ring 37b and thus from the portion 3c of the telescopic guide device 3.

After changing tool, drilling is subsequently performed in conventional manner, after taking care to close the orifice 31 by means of a valve (not shown) so that the drilling mud can be recovered at the surface for recycling in the drilling process.

In order to prevent the various portions 3b and 3c being rotated during screwing and unscrewing of the turbine body to the front end of the portion 3c, said portions 3a, 3b, and 3c may advantageously be in the form of square or hexagonal section tubes. If they are in the form of circular tubes, indexing is advantageously included in the sliding bearings 33.

The telescopic guide pipe 3a, 3b, and 3c is described above in an application associated with vertical drilling, however it is also applicable to deflected drilling, as shown in Figure 6A. The equipment and the operations remain substantially the same, it nevertheless being understood that the telescopic guide pipe 3 presents curvature in its inclined position, as

shown in Figure 6B, the guide device 3 being secured to the drilling baseplate at plane AA.

Figure 6B is a side view of a curved guide device 3 constituted by three telescopic pipe elements 3a, 3b, and 3c. The telescopic pipe element 3a is engaged in plane AA in a rigid external top structure 20 described in greater detail below with reference to Figure 17.

Figures 7 to 19 show the telescopic guide pipe 3 in the context of a deflected borehole, i.e. both in an inclined and curved position, and also in a retracted position, i.e. a position in which the various telescopic pipe elements 3a, 3b, and 3c are nested with the smaller elements inside the larger elements. That is why in the description below, when reference is made to said guide pipe, it is a telescopic guide pipe in the retracted position that is being referred to, i.e. one in which the smaller-diameter telescopic pipe elements are slid into the outermost telescopic pipe element. When reference is made to elements co-operating with said telescopic guide pipe, then reference is being made to the element co-operating with the outermost telescopic pipe element 3a as shown in Figures 1 to 5.

Figure 6A is a side view of a surface support 1 of the DTU type fitted with drilling equipment and processing equipment. A drilling riser 2 in a catenary configuration is connected to a guide pipe 3 by means of an automatic undersea connector 2<sub>1</sub>. The structure 3<sub>4</sub> represents means for controlled burying. A undersea well control assembly 2<sub>2</sub> is associated with this well entrance and serves to shut the well in the event of eruption. Drilling is performed in conventional manner from the surface via the drilling riser 2 and the guide device 3-3<sub>4</sub>, until the reservoir is reached.

Said drilling riser 2 deflects progressively from a substantially vertical position 2a at said floating support 1 to a position 2b that is substantially horizontal or tangential to the horizontal at the sea

bottom, with drilling being operated from said floating support 1 via said drilling riser 2 and the retracted telescopic guide device 3 in such a manner that the borehole begins in the sea bottom at a given angle of inclination  $\alpha$  relative to the horizontal, preferably lying in the range  $10^\circ$  to  $80^\circ$ .

The controlled burying means 3<sub>4</sub>, 5<sub>1</sub>-5<sub>3</sub>, 7<sub>1</sub>-7<sub>3</sub>, 8-9, and 13 shown in Figures 7 to 19 enable said retracted telescopic guide pipe 3 to be buried in the sea bottom when said retracted telescopic guide pipe 3 is subjected to traction T along the sea bottom from its front end 3<sub>1</sub>:

- starting from an initial position A1 in which said retracted telescopic guide pipe 3 rests entirely on the sea bottom in a position that is substantially horizontal;

- to a buried position A2 in the subsoil of the sea bottom, and in the buried position said retracted telescopic guide pipe 3 comprises in succession:

- a front end 3<sub>1</sub> resting substantially horizontally on the sea bottom;

- a curved intermediate portion of retracted telescopic guide pipes buried in the subsoil of the sea bottom and having a large radius of curvature, preferably a radius of curvature than 500 m; and

- a rear portion 3<sub>3</sub> at the rear end of said retracted telescopic guide pipe 3 buried in the subsoil of the sea bottom, said rear portion being substantially linear and inclined at said given angle of inclination  $\alpha$ .

In a first preferred embodiment of the invention, said controlled burying means comprise:

- a front soleplate 5<sub>1</sub> placed on the sea bottom and supporting said front end 3<sub>1</sub> of the retracted telescopic guide pipe, and secured thereto;

- at least one intermediate soleplate 5<sub>2</sub>, 5<sub>3</sub> supporting said curved intermediate portion 3<sub>2</sub> and/or the rear portion 3<sub>3</sub> of said retracted telescopic guide pipe and secured thereto, of surface area that is smaller than

that of said front soleplate 5<sub>1</sub>, and preferably a plurality of said intermediate soleplates 5<sub>2</sub>, 5<sub>3</sub> distributed along said intermediate portion 3<sub>2</sub> and the rear portion 3<sub>3</sub> of said retracted telescopic guide pipe 3, the soleplates being of decreasing area relative to said front soleplate on coming closer to said rear end 3<sub>3</sub> of the guide pipe; and

- an anchor 13 connected via 12 to said rear end 3<sub>3</sub> and suitable for becoming buried in the ground under the effect of said traction applied to said front end 3<sub>1</sub>.

It will be understood that in the first preferred embodiment of the invention as described above with reference to Figure 6B, said soleplates actually support the largest-diameter outer telescopic pipe element 3a.

Figure 7 shows this first version of the guide device of the invention in which the guide device is towed on site by means of a cable 10 connected to the front of the guide device via a traction head 11, the rear end of said guide device being connected by a second cable 12 to a very high performance anchor 13 of the Stevpriss® or Stevmanta® type from the (Dutch) supplier Vryhoff. The front portion 3<sub>1</sub> of the guide device is secured to a soleplate 5<sub>2</sub> of large surface area resting on the sea bottom in such a manner as to limit penetration into the ground. In the same manner, the smaller-sized soleplates 5<sub>2</sub>, 5<sub>3</sub> are distributed along the retracted telescopic guide pipe, with their respective load carrying areas decreasing on coming closer to the rear end 3<sub>3</sub> of said guide pipe. The front end 3<sub>2</sub> is also stabilized by a baseplate carrying a load 6 and secured to the soleplate 5<sub>1</sub>, thus causing the guide device to be engaged in said baseplate 6, as shown in Figure 8.

By exerting traction on the towing cable 10, the assembly pulls the anchor which begins to become buried (25), thereby entraining (24) the rear end 3<sub>3</sub> of the guide pipe. The circular shape of the guide pipe brakes penetration only moderately, whereas the soleplates 5<sub>2</sub>, 5<sub>3</sub>

distributed along the pipe oppose penetration with a force that is proportional to their area. Since the front soleplate  $5_1$  is of large dimensions, the front of the guide device remains on the sea bottom and the  
5 deadweight 6 stabilizes the assembly in such a manner that the axis of the guide device remains substantially horizontal, i.e. parallel to the sea bottom 4.

One method of making a guide device of this type consists in applying traction to the front end  $3_1$  of said  
10 retracted telescopic guide pipe 3 until said intermediate soleplates  $5_2$ ,  $5_3$  are buried in the ground at ever increasing depth on approaching the rear end  $3_3$  of the guide pipe so as to obtain the desired radius of curvature  $R$ , preferably greater than 500 m, and more  
15 preferably lying in the range 500 m to 1000 m.

In another preferred embodiment of the invention, shown in Figures 11, 12, and 13, said controlled burying means comprise at least one deflector  $7_1$ ,  $7_2$ ,  $7_3$  secured to the outer telescopic pipe element of said telescopic  
20 guide pipe 3 in said intermediate portion  $3_2$  or said rear portion  $3_3$  of the outer pipe element of the telescopic guide, said deflectors comprising plane surfaces that are preferably symmetrical about the vertical axial plane  $XX'$ ,  $YY'$  of said guide pipe in the longitudinal direction  
25 when it is in a rectilinear horizontal portion, and said plane surfaces of the deflectors are inclined relative to a horizontal plane  $XX'$ ,  $ZZ'$  of said guide pipe when it is in a horizontal position on the sea bottom, said deflectors  $7_1$ ,  $7_2$ , and  $7_3$  being inclined at respective  
30 angles  $\alpha_1$ ,  $\alpha_2$ , and  $\alpha_3$  so as to cause said guide pipe to become buried when it is pulled from said substantially horizontal initial position A1 to a said buried position A2 in the sea bottom.

These deflectors  $7_1$ ,  $7_2$ , and  $7_3$  serve to control the  
35 curvature of the retracted telescopic guide pipes as buried in the sea bottom since, once said deflectors are in a horizontal position, as shown in Figure 12, they



prevent any further burying of the pipe and stabilize it in the desired position A2. It will be understood that it is the spacing and the inclination of the deflectors which determine the curvature and more generally the shape of the retracted telescopic guide pipe in its buried position A2.

The guide device preferably comprises a plurality of deflectors  $7_1$ ,  $7_2$ , and  $7_3$  distributed along the outer pipe element of said telescopic guide pipe, said deflectors being inclined at angles  $\alpha_1$ ,  $\alpha_2$ , and  $\alpha_3$  that become smaller for deflectors  $7_1$ - $7_3$  closer to said front end  $3_1$ .

The guide pipe is thus fitted with a plurality of deflectors  $7_1$ - $7_3$  secured to the guide pipe and oriented at angles  $\alpha_1$ - $\alpha_3$  relative to the axis XX' thereof. The deflector  $7_1$ - $7_3$  is, for example, a simple plane metal sheet, preferably a reinforced sheet, and preferably disposed symmetrically about the vertical and horizontal axial planes XX', YY', and XX', ZZ' of the guide pipe, being welded to the guide pipe of the guide device as shown in Figure 12. The angles are adjusted initially during manufacture of the guide device so as to act in the same manner as the anchor 13 described with reference to Figures 7, 8, i.e. so as to cause the retracted telescopic guide pipe to become buried, with the depth of burial being limited by said angle  $\alpha$ . When traction T is exerted on the towing cable 10, the deflectors  $7_1$ - $7_3$  become buried locally entraining (24) the guide pipe until each deflector is substantially parallel to the traction force of the cable 10, i.e. substantially parallel to the sea bottom 4, or indeed substantially horizontal, in which position the deflector exerts no further vertical downward force tending to make the assembly move downwards.

A multitude of optionally identical deflectors  $7_1$ - $7_3$  are advantageously disposed along the guide device, each deflector presenting a respective angle  $\alpha_1$ - $\alpha_3$  that becomes smaller for deflectors closer to the front end  $3_1$ , as

shown in Figure 11. During penetration (24) into the ground, once all of the deflectors  $7_1-7_3$  have reached a substantially horizontal position, the assembly has taken on the desired curvature, as shown in Figure 12.

5        One method of making a guide device in this second embodiment consists in applying traction T to the front end  $3_1$  of said retracted telescopic guide pipe 3 until said deflectors  $7_1, 7_2, 7_3$  are buried in the ground in horizontal positions so as to obtain said desired radius  
10       of curvature which is preferably greater than 500 m, and more preferably lies in the range 500 m to 1000 m.

Figures 14 and 15 show another preferred version of the invention in which said controlled burying means comprise:

15       - secondary pipes 8 for jetting fluid 18 and secured to the outer telescopic pipe element of said guide pipe 3, extending parallel thereto along the underface thereof; and

20       - said secondary pipes 8 are small in diameter compared with said elements of said telescopic guide pipe 3 and have perforations 9 in their bottom faces enabling a fluid 18 to be expelled towards the sea bottom when said secondary pipes 8 are fed with a said fluid 18 under pressure.

25       Said secondary pipes 8 are preferably connected via their ends  $8_1, 8_2$  to the front and rear ends  $3_1, 3_3$  of said outer pipe element of said telescopic guide pipe, and they communicate with said front and rear ends  $3_1$  and  $3_3$  so as to make it possible to feed them using a single  
30       feed pipe 19 feeding said front end  $3_1$  of said telescopic guide pipe 3.

Figure 15 shows two secondary pipes 8 disposed symmetrically about the guide pipe 3.

35       Figure 14 shows a secondary pipe 8 connected via its two ends to the guide pipe 3 via check valves  $8_1, 8_2$ . Said guide pipe 3 is itself hermetically closed at both ends, firstly by the traction head 11 and secondly by a

stopper 14. One orifice is connected via a water feed pipe 19 to the surface vessel 1 having the necessary pumping means. Thus, during towing, the guide pipe can be lightened by being filled with gas under pressure via the pipe, excess pressure escaping through the check valves 8<sub>1</sub>, 8<sub>2</sub>, and then via the orifices 9 in the secondary pipes 8. Once the assembly is on the sea bottom 4, the same pipes 8 have, advantageously, water injected into them under high pressure, thereby making the assembly heavier by filling the guide pipe 3, and then breaking up the underlying ground, thus making it easier to bury the guide pipe.

A method of implementing a guide device of the above type comprises the following steps:

- a gas under pressure is injected into said secondary pipes 8 while it is desired to tow the retracted telescopic guide pipe 3 over the sea bottom; and
- a liquid, preferably water, is injected under pressure into said secondary pipes 8, and preferably into said telescopic guide pipe 3 closed at its ends 3<sub>1</sub>, 3<sub>2</sub> and communicating with said ends 8<sub>1</sub>, 8<sub>2</sub> of said secondary pipes when it is desired to bury said retracted telescopic guide pipe 3.

In another preferred version of the invention shown in Figure 16 to 19, it is advantageous to associate any of the devices shown in Figures 7 to 15 with a rigid outer top structure 20 engaged on the front end 3<sub>1</sub> of the telescopic outer pipe element of the guide pipe 3, the assembly resting on the ground via lateral soleplates 21 as shown in Figure 19 which is a section on plane DD.

More precisely, the guide device comprises:

- a rigid outer top structure 20 covering and holding in a straight line said retracted telescopic guide pipe 3 while it is substantially horizontal and resting on the sea bottom;

- said outer structure 20 has a longitudinal central opening in its bottom face allowing said retracted telescopic guide pipe 3 to become buried in the ground when traction T is applied thereto;

5       - at least one connection  $17_1$ ,  $17_2$ ,  $17_3$  connecting at least the rear portion  $3_3$  of the outer telescopic pipe element of said retracted telescopic guide pipe to said outer structure 20 in such a manner as to prevent it from becoming buried beyond a given depth so as to limit the  
10       radius of curvature R of said curved portion;

- said outer top structure 20 resting on the ground of the sea bottom 3, preferably via lateral soleplates 21 situated on either side of said longitudinal central opening 22, said lateral soleplates 21 preventing said  
15       rigid outer structure 20 from becoming buried; and

- said outer structure 20 being secured to said baseplate 6 in which said front portion  $3_1$  of the outer telescopic pipe element of said retracted telescopic guide pipe 3 is engaged.

20       The ordinary portion of the guide pipe is free to move vertically through the central opening 22 of the structure 20, as shown in Figure 18 which is a section on plane CC, with structural elements 33 restricting lateral displacements.

25       The guide device preferably comprises:

- a plurality of flexible connections  $17_1$ ,  $17_2$ ,  $17_3$  distributed along the outer telescopic pipe element of the telescopic guide pipe 3 and presenting lengths that increase on going towards the rear end  $3_3$  of the guide  
30       pipe 3, in such a manner that said guide pipe presents a said curved portion having the desired radius of curvature R and a said rear portion  $3_3$  that is linear.

These flexible connections  $17_1$ ,  $17_2$ , and  $17_3$  are constituted, for example, by cables or chains connected  
35       first to the external structure 20 at 26 and secondly to the guide pipe at 27. These connection points 26-27 are shown in Figure 17. The flexible connections  $17_1$ - $17_3$  are

distributed along the guide pipe in uniform manner or otherwise, and they are of various lengths, becoming shorter on approaching the front  $3_1$  of the outer telescopic pipe element of the guide pipe. Their positions and their lengths are determined in such a manner that at the end of penetration into the ground, when all of them are under tension, the desired curve is obtained as shown in Figure 17. To prevent the structure becoming buried in the ground, a multitude of lateral soleplates 21 are installed on its bottom face, so as to establish a sufficient bearing area.

A method of implementing a guide device of the above type consists essentially in applying traction T to the front end  $3_1$  of the outer pipe element of said telescopic guide pipe 3 and to said rigid outer structure 20 secured to said guide pipe until said connection(s)  $17_1-17_3$  prevents at least said rear portion  $3_3$  of said retracted telescopic guide pipe from becoming buried any deeper, so as to obtain the desired radius of curvature R which is preferably greater than 500 m, and more preferably lies in the range 500 m to 1000 m.

All of these controlled burying means  $5_1-5_3$ ,  $7_1-7_3$ , 13, 20,  $17_1-17_3$  of the invention described with reference to the various above embodiments can be implemented either individually or in combination, since the nature of the ground can sometimes make extremely powerful means necessary if the ground is very cohesive.

The outer structure 20 is preferably continuous along the guide pipe and represents an additional mass of 25 to 75 tons. Jetting is performed using pressurized water raised at the surface to pressures lying in the range 20 bars to 100 bars and applied to the secondary pipes 8.

By way of example, with a telescopic guide device, the portions 3a, 3b, and 3c have respective diameters of 21" (0.55 m), 18" (0.45 m), and 16" (0.40 m), and each of them has a length lying in the range 100 m to 150 m.

By way of example, for a guide device for drilling vertically as shown in Figure 20, the telescopic pipe elements are five in number having respective diameters of 30", 24", 21½", 18¾", and 16", each of the telescopic pipe elements measuring about 200 m in length, giving a total deployed length of about 1000 m. A prior art set of casings having the same inside diameter of 16" would have respective decreasing diameters of 36", 30", 24", 20", and 16". The assembly would likewise measure about 1000 m, but because each casing element extends downwards from the level of the sea bottom, the total length of the assembly represents an accumulated length of about 3000 m of pipe, and that constitutes a weight of steel that is approximately 2 to 2.5 times greater than the weight of steel needed to make the telescopic casing of the invention.